

**SECTION - VII**

**TECHNICAL SPECIFICATIONS  
FOR CONTROL, METERING, PROTECTION AND  
COMMUNICATION SYSTEMS**

**7.1 GENERAL**

It is planned to provide this Power Station with the systems based on state of art technologies of control, metering, protection, communications and remote control. The equipment offered against this section of specification shall meet the requirements and specification laid down herein, shall be based on the latest techniques in the respective fields and conform to the relevant Indian / International Standards and codes of practices.

**7.2 SCOPE**

The scope includes design, manufacture, shop testing, delivery, erection, testing, commissioning and training of purchasers' personnel for computer based automation systems for the operation of power plant and switchyard from any control point that can be local, and remote. The scope also includes data logging, alarm monitoring, unit control, protection, metering, communication system and other components for making the system complete and to ensure a trouble free and safe operation **on turnkey basis**. The power station will comprise the following major components:

- i. 3x1.5 MW Synchronous Generating units, Francis turbines being the prime mover and synchronized at 3.3 kV, brushless excitation and governing systems being digital.
- ii. 3 step up generator transformers of the rating 3.3 kV/33 kV 2.0 MVA.
- iii. 2 no. 33 kV Feeder
- iv. 1 No. 250 kVA, 3.3 kV/415 V station transformer.

Following drawings show tentatively the equipments to be controlled:

E-127-2 CT/PT /single line diagram/indicating CT/PT, Metering and Protection scheme

**7.2.1 Control Equipment and Data Acquisition**

The control equipment shall comprise following:

**a. Generating Units Control**

- i. Local manual control of generating units from hard wired control panels located in the control room as well as near the respective units.
- ii. Local automatic control of generating units from control panels located in the control room as well as near the respective units by PLC based unit controllers.

**b. Switchyard Control**

- i. Manual control from hard wired control panels located in the control room.
- ii. Automatic control from computer based unit controller in the control room using a remote terminal unit (RTU) located in the switchyard if required.

**c. Data Acquisition**

The PLCs will acquire data from generating units, transformers, 33 kV switchgear, auxiliaries, transducers/sensors, CTs and VTs, etc. as necessary for their optimal operation. Wherever signals are weak or there is strong noise due to EMI or RI etc, shielded cables shall be used to carry signals/data.

**Notes:**

- i. The control equipment offered should have been in successful operation for 2 years in at least 2 power stations. Certificates to this effect from the users shall be submitted by the bidder.
- ii. The UPS required for the PLCs system and the batteries needed for the UPS for 1-hour backup shall also be supplied by the contractor.
- iii. Calculation for kVA rating of the UPS and battery specifications shall be submitted by the bidder for purchaser's consideration.

**7.2.2 Synchronization**

Manual synchronization shall be provided in addition to computer-based auto-synchronization with an appropriate change-over switch on the control panel.

**7.2.3 Alarm and Annunciation**

Window annunciation shall be provided on the control panels in the control room as well as those near the generating units and the same shall be complete with audio and video alarm system. The system shall be designed to have low DC power consumption.

**7.2.4 Metering**

- i. All panel meters shall be digital with at least 2 cm digit size, at least three-and-a-half digit LED display and accuracy class of 1.0.
- ii. Energy metering shall be provided on the 33 kV and generators with microprocessor based trivector meters of an accuracy class of 0.2 or better.
- iii. Electronic energy meters of accuracy class of 1.0 or better will be provided for metering at 250 kVA station transformer.

**7.2.5 Protection Relays**

- i. Each generator and generator transformer shall be provided with a multifunction digital relay incorporating all protection functions, measurements and fault data logging features.

- ii. Generators and generator transformers shall have additional protection using static (analog) relays.
- iii. Digital relays shall be provided for the protection of feeder and station transformer.

### **7.2.6 Temperature Scanners**

Temperature scanners and suitable printer shall be installed for stator windings, bearing temperatures and transformers including cables from temperature sensors. The scanners shall have two alarm settings for high temperature for each point adjustable over the entire range. There shall be one scanner for each generating unit along with generator transformer. Each scanner shall have at least 32 channels.

### **7.2.7 Control Panels**

The following control panels fitted with necessary devices and appropriately wired using standard accessories shall be provided and located in control room. Each functional control panel listed below can physically be comprised of more than one panel.

- i. Unit control panel for each generating unit and generator transformer.
- ii. Station transformers control panel.
- iii. Synchronizing panel.

In addition, a unit control board fitted with necessary devices shall be installed on the machine floor close to each generating unit for controlling its operation locally.

### **7.2.8 Local Communication**

The scope shall cover supply, erection, testing & commissioning and handing over to owner of a digital electronic private exchange of 8/10 lines along with 8/10 telephone sets, including connection to subscribers for voice communication. The exchange will work on 48 V D.C.

Voice communication system shall have to be integrated with BSNL or other telephone communication network.

### **7.2.9 Completeness**

All such systems/equipment/components/works which are necessary for the completeness of the system but not mentioned explicitly shall also be a part of the scope of the contractor. The control room shall be dust-free and air-conditioned as described elsewhere.

### **7.2.10 Spare Parts & Tools**

The contractor shall ensure supply of the spares for all the offered equipment/components (at least one module of every type) for use for 5 years and any special tools and plants, spanners etc. required for site assembly, erection, testing, commissioning, operation & maintenance of the equipment.

### **7.2.11 Documentation**

The contractor shall provide all necessary drawings, diagrams and documentation of equipment and software. The documentation in original shall also include six hard copies and one soft copy of the following:

**a. Hardware:**

The necessary user, reference and service manuals along with the technical specifications for all the hardware systems/sub-systems shall be supplied by the contractor. The extent of documentation to be furnished shall be to the satisfaction of the Purchaser.

**b. Software:**

User and reference manuals related to complete software shall be supplied by the contractor. The extent of the documentation to be furnished shall be to the satisfaction of the Purchaser.

### **7.3 STANDARDS**

Standard and codes to which the equipment must conform are given in Annexure 6/1.

### **7.4 FUNCTIONAL REQUIREMENTS**

#### **7.4.1 Automation System**

##### **7.4.1.1 Control Options**

Computer-based automation systems shall permit operation of the power plant and switchyard from each of the three control points, namely local and remote. Local manual control shall also be provided in the equipment as a backup.

##### **7.4.1.2 Unit Controllers**

Local control will be provided by equipment located near the generating unit as well as in the control room. For each generating unit, there will be an independent PLC based unit controller. Back up manual control shall be provided for each unit. Suitable remote terminal units (RTUs) shall be provided in the switchyard and at station auxiliaries to enable control of the switchyard equipment and station services.

Each PLC will have a dual power unit. The main power unit will work on 48 Volts D.C. and the hot-standby power unit will take power from a UPS at 240 Volts A.C.

## **7.4.2 Unit Control**

### **7.4.2.1 Control Functions**

The unit controllers will control the generating units individually and shall perform following functions:

- i. Governor control
- ii. Excitation control
- iii. Sequence control
- iv. Alarm and annunciation
- v. Synchronization
- vi. Input from transducers & sensors
- vii. Output to actuators
- viii. Communication
- ix. Active power control
- x. Reactive power control

### **7.4.2.2 Auto Start/Stop**

The equipment controlled and monitored during the start/stop sequence will include the following:

- a. Main inlet valve;
- b. Governor hydraulic oil system;
- c. Guide Vane operating mechanism;
- d. Cooling water system;
- e. Excitation equipment;
- f. Unit speed;
- g. Protective relaying status;
- h. Unit alarms;
- i. Unit breaker status;

### **7.4.2.3 Diagnostic Information**

Automation system shall have capability to provide diagnostic information in the event something fails to operate during the start sequence/running.

The protective relays and devices of generator and turbine are proposed to be grouped into four categories subject to modification by purchaser in consultation with contractor/equipment supplier.

#### 7.4.2.4 Control Scheme of Turbine

##### (a) Controlled action shut down

Controlled action shutdown will be initiated by any of the following conditions.

- Generator thrust bearing pads temperature very high
- Generator guide bearing pads temperature very high
- Turbine guide bearing pads temperature very high
- Governor OPU oil level low stage-II
- Governor OPU oil pressure low stage-II

The controlled action shut down system will not cause immediate tripping of the generator and field breaker but smoothly transfer load and initiate tripping of generator transformer breaker & field breaker only when entire load is transferred.

Trip Alarm in control room and VCB will operate.

##### (b) Emergency Shut down

Emergency shutdown will be initiated by any of the following conditions.

- Speed 115% and deflector apparatus not moved to closing
- Guide vane fail to close in preset time
- Unit over speed (electrical)>140%
- Unit over speed (mechanical)>150%
- Stop push button on unit control board is pressed.
- Stop push button on control panel in control room is pressed.

Emergency shut down system will perform following functions:

- a) Trip 3.3 kV main generator transformer breaker
- b) Stop turbine by governor action
- c) Trip generator field circuit breaker
- d) Operate trip alarm in control room/UCB/
- e) Energizes emergency solenoid valve in governor cubicle to stop the turbine by bypassing governor.
- f) Close main inlet valve

##### (c) Immediate Action Shut down

Immediate action shut down will be initiated by any of the following conditions:

- Generator differential protection operates
- Generator stator earth fault protection operates
- Generator field failure protection operates
- Generator transformer stand by earth fault protection operates
- Over current in stator
- Over current instantaneous protection in the excitation circuit (if provided)

The immediate action shut down will perform following function.

- Trip generator transformer breaker
- Trip field breaker
- Initiates controlled action shut down.
- Stop turbine by governor action.
- Trip annunciation in control room/UCB.

**(d) Electrical shut down**

Electrical shutdown system will be initiated by any of the following conditions.

- Over current in the excitation circuit (if provided)
- Generator back up protection operates
- Generator over voltage protection operates.
- Excitation failure protection operates.
- Reverse power protection operates.
- Generator T/F IDMT over current, over current instantaneous & earth fault protection operates.

Electrical shut down system will perform following functions:

- (i) Trip generator transformer breaker
- (ii) Trip field breaker
- (iii) Governor brings the unit to spin at no load.

**7.4.2.5 Synchronization**

Automation system shall be capable of auto synchronising. A synchronising check relay will be provided.

**7.4.2.6 Turbine Operation Optimization**

Optimization of energy generation will be ensured by monitoring water level of the forebay. For this purpose signals shall be taken from the level transducers on forebay.

**7.4.3 Protection**

Protection relay panels for the generating units and 3.3/33 kV generator transformers shall use microprocessor based (digital) and static (analog) relays as described in Generator Protection. The 33 kV feeder shall be protected with microprocessor based digital relay as described in 33 kV line protection herein after. Protective relays for other equipment shall be digital type. Details of protection requirements are shown tentatively in drawing No.E-127-2.

**7.4.4 Metering**

The metering equipment (Meters, CTs and VTs) will meet the requirements shown in drawing no. E-127-2.

#### **7.4.5 Auxiliary Power**

The auxiliary power at 415 V shall be taken from the 3.3 kV bus through one station transformer and distributed as per requirement.

#### **7.4.6 D.C. Supply**

The D.C. power at 48 V for all controls, circuit breakers, relays and meters etc. shall be obtained from one set of station battery. The battery bank shall have 300 AH capacity tentatively and shall be float and boost charged from separate rectifier units. Tentative details of charging arrangements and distribution are shown in drawing no. E-127-4. Further details are given in subsequent paras. Calculations for the capacity of batteries shall be submitted by the bidder for the consideration of the purchaser.

### **7.5 SYSTEM ARCHITECTURE & COMPONENTS**

- i. Open architecture system shall be followed in accordance with IEEE-1249-1996. Interface and operating standards/protocols for the following shall be intimated and should comply with ISO/IEC 12119:

Time stamping of data,  
Communications  
Operating system  
Data base

- ii. Each of these elements should be capable of being replaced by and communicating with system elements provided by other vendors.
- iii. The scope of the bidder is not limited to the parts & components explicitly identified here in and shall have to provide any and all parts/components needed to meet the functional requirements laid down herein.

### **7.6 PROTECTION AND METERING DETAILS**

#### **7.6.1 Protection and Metering Scheme**

Requirements of metering and protection/scheme and the function performed by various relays are explained in following tentative drawings:

- i. E-127-2      Single Line Diagram CT/PT and equipment scheme
- ii. E-127-5      Station service board & distribution board

All the protective relays will be housed in the control room of the Power Plant. The tentative locations of C.T.s and P.T.s housed in GT and NG cubicle for the protection and metering. Alternative arrangements may be proposed by the bidder.

The final drawings for the protection & metering shall be submitted by the contractor and will be subject to the approval by the Purchaser.

## 7.6.2 CTs / VTs

All current and voltage transformers required for protection system of the unit shall have adequate VA burdens, knee point voltage, saturation factor and characteristics suitable for the application, and shall be subject to approval of the Owner.

## 7.6.3 Special Features of Proposed Protection System

- i. The protection system shall be built on latest technology and the bidder has to guarantee for supply of spares for at least 10 years. Moreover, the bidder should have full range of manufacture of the system offered.
- ii. Wide setting ranges with fine setting steps for each protection shall be available.
- iii. The offered system shall have proven record of satisfactory performance for at least 2 years and in two power stations. Necessary certificates to this effect shall be a part of the offer.
- iv. The protective relays shall preferably be housed in draw out type of cases with tropical finish.
- v. Common tripping relays (each for similar functions) will be provided with lock-out facilities. All these relays shall have potential free contacts for trip and alarm purposes and externally hand reset type of flag indicators

## 7.6.4 Generator And Transformer Protection

7.6.4.1 An integrated numerical protection relay incorporating the following functions shall be provided for each generator:

### Generator

- i. Generator differential (High impedance circulating current) (87 G)
- ii. Negative phase sequence (46)
- iii. Generator reverse power protection (32)
- iv. Voltage restrained over current protection (51V)
- v. Stator earth fault protection (64S)
- vi. Loss of excitation protection (40)
- vii. Over frequency protection (81)
- viii. Rotor earth fault protection (64R)
- ix. Over voltage protection (59)
- x. Our speed relay-Mechanical And Electrical (12)

**Transformer**

- i. Generator transformer differential protection.
- ii. Generator T/F over current and earth fault protection with high set instantaneous element (50, 64)
- iii. Generator T/F stand by earth fault protection (64 GT)
- iv. Measurements
- v. Sequence of events recording
- vi. Disturbance recording
- vii. Self diagnosis and supervision

7.4.6.2 In addition, the following static (analog) protective relays shall be provided:

- i. Negative phase sequence relay (46)
- ii. IDMT Over current relay (51)
- iii. Reverse power relay (32)
- iv. Stator earth fault protection (64G)
- v. Generator T/F stand by earth fault protection (64 GT)
- vi. Check synchronizing relay (25)

The bidder may propose additional protection as an option.

7.6.4.3 Following protection provided on the generator transformers shall also be integrated with the main protection described above:

- i. Oil temperature indicator with alarm
- ii. Buchholz relay with alarm and trip control.
- iii. Winding temperature indicator with alarm and trip control
- iv. Oil gauge with low-level alarm.

7.6.4.4 Following mechanical protections shall be provided:

- a. Resistance temperature detectors (Pt-100) in stator core (12 no.) and in the bearings for indication, alarm and recording. RTD's are to be provided by Generator Suppliers.
- b. Turbine and generator bearing, metal and oil temperatures – alarm/shutdown.
- c. Governor oil pressure low to block starting and very low for emergency tripping.
- d. Over speed for normal and emergency shutdown depending upon its extent.

**Note:** Though the generator shall be synchronized at 3.3 kV, neutral displacement protection has been provided through a neutral grounding transformer of 5 kVA rating with a ratio of  $3.3/\sqrt{3}$  kV /  $110/\sqrt{3}$  volts (Ratings are tentative and subject to confirmation). There shall be a provision in the relay for time grading to avoid operation of the relay function on 33 kV bus fault. The ratings of this transformer are tentative, the bidder shall submit detailed calculations.

### 7.6.5 33 kV Line Protection

A numerical directional inverse-over current and earth fault relay with high set unit shall be provided on 33 kV line.

### 7.6.6 Station Transformer And Distribution Transformer Protection

Station supply is provided through 1 No. 3.3/0.415 kV 250 kVA station transformer. This transformer will supply power to all the auxiliaries of the unit and station general supply.

The following protection will be provided on the transformer.

#### (i) 3.3 kV side of transformers

- (a) Digital IDMT over current and earth fault relay with high set instantaneous element (50/51/64.)
- (b) T/F winding temp high alarm/trip control.
- (c) T/F oil temperature high alarm
- (d) Buchholz relay with alarm and trip control

#### (ii) LV side of the transformers

Digital IDMT over current & earth fault protection with high set instantaneous element (50/51/64).

## 7.7 CONTROL PANELS

### 7.7.1 Constructional Features

- i. All control panels shall be of standard construction, dimensions, materials and sheet thickness.
- ii. Control panels shall be of simplex types (devices mounted on the front panel and double door on the back side).
- iii. Panels shall be painted by dry electro-static powder coating process.
- iv. All accessories mounted on the front panel shall be flush mounting type.
- v. Each control panel will have mimic diagram embossed and painted on its front.
- vi. Each panel will have arrangements for internal lighting and heating.
- vii. The wires and wiring accessories, terminations, colour scheme etc. shall be as per relevant Indian Standards.

### 7.7.2 Unit Control Panels

The unit control panel for each generating unit shall accommodate necessary relays, measuring instruments, indicators, control unit, control switches, annunciator, temperature scanner etc. for the operation of the generating unit from control room. The generating units shall be controlled from this control panel during starting, stopping and normal running in manual and auto modes. Some important controls, instruments, annunciators etc. shall be duplicated or additionally provided on a unit control board mounted in machine hall near governor cabinet for operation of the unit, details of which shall be decided in consultation with the purchaser.

### 7.7.3 Synchronizing Panel

Synchronizing equipment with check feature shall be provided for synchronization of the generating units at the 3.3 kV bus bars and shall comprise of a centrally positioned panel. All the indicating meters with associated switches and fuses should be mounted on the upper half of Central panel so that it is easily visible to the operator.

Synchronising switch shall be mounted near each circuit breaker control switch on the respective unit control panel. Contacts provided in each switch shall be connected in the closing circuit of the respective breaker so that the breaker cannot be closed until the switch is turned to the “Synchronising” position. Switches shall be arranged so that the handle will be locked only in the ‘OFF’ position and check synchronizing relay shall be provided, so that the breaker could be closed only when voltage, frequency and phases are properly matched.

Provision for closing the breaker without synchronising check should also be made with the check synchronising switch in OFF position.

All necessary interlocks, auxiliary potential transformers, auxiliary relays, wiring of the synchronizing bus inside the control panel, fuses, clamps and other accessories for satisfactory synchronizing operation shall be provided by the contractor. The synchronizing scheme is subject to purchaser’s approval.

### 7.7.4 Station Transformer Control Panels

One control panel for the station transformer and other for distribution transformer shall be provided complete with necessary relays, measuring instruments, indicators, control switches, annunciator etc.

## 6.8 ANNUNCIATION SYSTEM

A multipoint microprocessor based annunciator with suitable number of ways for projecting visual signals and audible alarm in case of fault shall be provided on the control panels suitably. The annunciator shall be back connected flush mounting, dust tight and tropicalised and shall be complete with audible warning device, and apparatus as required to complete the annunciator system. It shall be suitable for operation on 48 V.D.C. supply.

The operation of the annunciator system shall be as follows :-

- (i) When an external initiating contact is closed, the audible warning shall sound continuously and the appropriate facia shall be illuminated by flashing light.
- (ii) An “acknowledge” push button shall be provided on control desk and near the annunciator unit which when pressed shall stop the audible signal and cause the facia to remain illuminated steadily.
- (iii) The annunciator facia illumination shall normally be designed to retain the indication after the re-opening of the initiating contact. A “reset” push button shall restore the annunciator to the normal condition.

- (iv) A test button shall be provided close to the “acknowledge” and “reset” buttons to illuminate all the facias on the associated display unit for as long as the “test” button is held in pressed condition.
- (v) In case there is a second fault on a system when the first is already being shown by the facia, the annunciator shall show the second fault also even when the first is existing on facia.

The following facilities shall be provided with each of the annunciator points :-

- i) It shall be possible to use “Normally open” type contacts as initiating contacts for the annunciator. It shall also be possible to use a few “Normally closed” type of initiating contacts, if required.
- ii) Provision shall be included with each annunciator point for remote indication at other control boards.

It will be the responsibility of the contractor to provide all the alarms and annunciations required for the safe and efficient operation of the power station.

An A.C. operated relay with A.C. buzzer and A.C. indicating lamp with reset push button shall be supplied for annunciation of D.C. supply failure.

Alarm horns, flicker light relays, necessary hardware and any other auxiliary equipment required to complete the annunciation system shall be provided.

## **7.9 FACTORY TESTING**

### **7.9.1 Equipment Tests**

Each individual equipment shall be routine tested as per IEC/IS at the work's of supplier in presence of Owner.

### **7.9.2 System Tests**

The contractor shall organize and execute a complete factory test of the system. The system shall be erected in his workshop in the engineered configuration and shall be tested for the following:

- i. Operation requirements
- ii. Operating characteristics
- iii. Response times
- iv. Software functions
- v. Deficiencies

Various process signals shall be simulated for carrying out above system tests. The Supplier shall submit routine test reports of each equipment and the total system.

## **7.10 SITE TESTING**

The contractor shall carryout tests at site as per relevant IEC/IS standards as follows in the presence of and to the entire satisfaction of the owner:

- i. Calibration checks (on sample basis) on all factory calibrated meters and transducers.
- ii. Acceptance tests on all other devices fitted on the control panels and earlier tested in factory.
- iii. IR tests on panels.
- iv. Continuing and IR tests on external cablings.
- v. Calibration checks/acceptance tests on all devices and equipment connected to the control panels.
- vi. Functional checks on each equipment/object controlled from unit controllers with control circuits de-energised.
- vii. Functional checks on controllers with power circuits de-energised.
- viii. Verification of all manual control functions from unit control panels.
- ix. Verification of all control sequences from unit controllers with power and control circuits energised.
- x. Watch up each generating unit and perform all start/stop sequences on it.

## **7.11 TRAINING**

Training of the personal of the department shall be arranged by the Contractor at the suppliers works and project site.

ANNEXURE-7/1**CODES OF PRACTICE AND STANDARDS**

IEEE Std 1249 – 1996	Guide for computer based control of hydroelectric plant automation
IEEE Std 1020 – 1988	Guide for control of small hydro plant
IEEE Std1010 – 1987	Guide for Control of Hydro Electric Power Plant
IEEE 2519	Power Quality
IEC 687	Alternating current static watt-hour meters for active energy
IEC 225	Electric relays
IEC 68	Environmental testing
IEC 60255-21-1	Vibration
IEC 60255-21-2	National Electrical Code
IEC 60255-1-3	Earthquake
IEC 801-2/4	Static discharge test
IEC 801-3/3	Electromagnetic fields
IEC 801-4/4	Transient fast burst test
IEC 801-5	Surge withstand test
IEC 801-3	Dielectric tests
EN 5501/COSPR11	Emission, terminal disturbance
EN 55011/CISPR11	Emission, radiation disturbance
IEC 62000-4-6	Electromagnetic fields
IEC 61000-4-3	
IEC 61000-4-4	Fast transients/Bursts
IEC 61000-4-5	Surge voltage
IEC 61000-4-11	Voltage dips
IEC 60255-22-1	1MHz Burst disturbance
IEC 68-2-1 & 68-2-2	Temperature
IEC 68-2-30	Humidity
IEC 68-2-6	Vibration of Unpackaged Products
IEC 68-2-27	Shock of Unpackaged Products
ASTM D999-75	Vibration of Packaged products
ASTM D775-80	Shock of Packaged products
IEC 1000-4-2	Electrostatic Discharge Immunity
IEC 1000-4-3	Radiated Electromagnetic Immunity
IEC 1000-4-5	Surge Transient Immunity
IEC 1000-4-4	Electrical Fast Transient/Burst Immunity
IEC 1000-4-6	Conducted Electromagnetic Immunity
CISPR 11 (EN55011)	Radiated Emissions
UL94V	Flammability and Resistance to Electrical Ignition